Appendix C-T9. Wildlife calculation methods and models and direct measures

Calculation methods and models		
Method: Bioaccumulation and biomagnification		
Description: Estimation methods using measured or estimated COC in food or prey and published accumulation factors from the literature. **Measurement endpoints:** Estimated concentrations in receptor organisms. **Test organisms:** All. **References:** USEPA 2006b, Weisbrod et al. 2007, Van Wezel et al. 2000	**Advantages:** Simple, inexpensive method to estimate exposure levels. Readily implementable. **Disadvantages:** Does not include site-specific factors, including bioavailability.	**Analyte capability:** All chemical classes
Method: USEPA allometric food intake assessment		
Description: Allometric equations developed to estimate total oral dose of a chemical based on intake of food, water, or sediment with consideration of species home range, weight, consumption rates, and food preferences. **Measurement endpoints:** Daily oral dose to receptor organism. **Test organisms:** Originally developed for select birds and mammals, have been applied to a wide range of species including reptiles and marine mammals. **References:** Baron, Sample, and Suter 1999; Sample and Suter 1999	**Advantages:** Simple, inexpensive method to estimate exposure levels. Can be adjusted to consider bioavailability where information is available. Requires only a literature search and a spreadsheet calculation. **Disadvantages:** Does not include site-specific factors, including bioavailability.	**Analyte capability:** All chemical classes
Method: Bioenergetics-based modeling		
Description: Models constructed to estimate exposure based on estimating oral intake from the target receptors' bioenergetic requirements, contaminant assimilation efficiencies, tissue conversion factors, and clearance rates. **Measurement endpoints:** Estimated tissue residue concentrations. **Test organism categories:** Principally applied to avifauna. **References:** Norstrom et al. 2007, Nichols et al. 2004, Karasov et al. 2007	**Advantages:** Moderately complex modeling exercise that depends on effective parameterization of the model equations. Requires collaboration between knowledgeable bird ecologist, toxicologist, and computer modeler. **Disadvantages:** Model parameters are not available for all species, introducing uncertainty into the model estimates.	**Analyte capability:** Persistent organic compounds

Direct measures		
Method: Bioaccumulation and biomagnification		
Description: Evaluates uptake of a chemical into a predator relative to that of its prey. For HOCs, the concentrations are lipid normalized. For metals, the units are mg/kg wet weight. Biomagnification is said to occur when the BMF > 1. **Measurement endpoints:** Concentration in predator, concentration in prey % lipids. **Test organism categories:** Can be used for all aquatic and aquatic-dependent wildlife. **References:** Foley et al. 1988; Bergman et al. 1994; Leonards et al. 1997; Wolfe, Schwartzbach, and Sulaiman 1998	**Advantages:** May be used to estimate concentrations in higher trophic level fish, birds, or mammals based on measured or previously reported BMFs or to validate more complex food web models. **Disadvantages:** BMFs derived from literature sources may not reflect site-specific conditions. Site-derived BMFs implicitly assume that all exposures occur within the area under investigation.	**Analyte capability:** All
Method: Field tissue residue and effects assessments		
Description: Receptor organisms are harvested from the field and brought to the laboratory and tissues are measured for target chemical(s). Field observations can also include clutch size, eggshell thinning, fledge success. **Measurement endpoints:** Tissue residue COCs, lipids, whole body, clutch size, eggshell thickness, fledge success, subcellular biomarkers. **Test organism:** Most commonly applied to bird species. Whole-body measures not applicable for T&E species. **References:** Custer and Custer 1995, Custer et al. 1999, Anteau et al. 2007, Overman and Krajicek 1995	**Advantages:** Integrates all pathways of exposure and provides a direct number for assessing risks. **Disadvantages:** Assumes all prey consumed are within contaminated area, which may not be valid for all predators. Not suitable for T&E species. Moderately to difficult to implement. Requires capture of suitable numbers and types of target receptors for evaluation in statistically meaningful way.	**Analyte capability:** All chemical classes
Method: Site-specific in situ dietary intake/effect studies		
Description: Nest boxes are placed immediately proximal to a contaminated site and monitored for reproductive effects. Measures include gut content identification and COC analysis, tissue analyses, clutch size, eggshell thickness, and reproductive success. **Measurement endpoints:** Adult growth (weight), mortality, clutch size, eggshell thickness, fledge success. **Test organisms:** Tree swallows, house wrens. **References:** Custer et al. 1998, 2001, 2003, 2005	**Advantages:** Relatively inexpensive. Integrates multiple chemicals in prey organisms with direct measures of site-specific uptake and effects. **Disadvantages:** Assumes dose is wholly dependent on foraging occurring within the contaminated site. Good assumption for large sites, not practicable for small sites.	**Analyte capability:** All chemical classes

Method: Site-specific ex situ dietary intake/effect studies		
Description: Fish or other prey items from the contaminated site are collected, formulated into diets, and fed to surrogate species. **Measurement endpoints:** Adult growth (weight), assimilation efficiency, COC uptake, mortality, litter or clutch size, pup weight gains, eggshell thickness **Test organisms:** Minks and otters. **References:** Sample and Suter 1999; Smits, Wobeser, and Schiefer 1995; Bleavens et al. 1984	**Advantages:** Integrates multiple chemicals in prey organisms with direct measures of uptake and effects. **Disadvantages:** Expensive and can take considerable time if multiple generations are involved. Not suitable for T&E species.	**Analyte capability:** All chemical classes
Method: Direct toxicity assessments		
Description: Target wildlife species are directly exposed to COCs in controlled laboratory environments. **Measurement endpoints: A**dult growth (weight), assimilation efficiency, COC uptake, mortality, litter or clutch size, pup weight gains, eggshell thickness. **Test organisms:** All species. **References:** Flemming et al. 1985, Clark et al. 1987, Camardese et al. 1990	**Advantages:** Integrates multiple chemicals in prey organisms with direct measures of uptake and effects. **Disadvantages:** Expensive and can take considerable time if multiple generations are involved. Not suitable for T&E species.	**Analyte capability:** All chemical classes
Method: Plasma COC assessments		
Description: Plasma from receptor organisms is collected from the field, brought to the laboratory, and measured for target chemical(s). **Measurement endpoints:** Plasma COCs, percent lipids. **Test organisms:** Principally used to assess chemical levels in T&E species and/or juveniles. **References:** Elliot et al. 2001, Bowerman et al. 2003, Strause et al. 2007	**Advantages:** Integrates all pathways of exposure and provides a direct number for assessing risks without killing receptor. **Disadvantages:** Sampling generally limited to few individuals. Resource-intensive. Plasma COCs not associated with specific toxicological effects. Moderately to difficult to implement. Requires capturing or accessing receptors and collecting samples, which may inflect damage on target species.	**Analyte capability:** All chemical classes
Method: Fur or feather COC assessment		
Description: Field collected fur or feathers are collected and analyzed for target COCs. **Measurement endpoints:** COCs, percent lipids. **Test organisms:** Principally used to assess chemical levels in T&E species and/or juveniles. **References:** Monteiro and Furness 1997; Scheuhammer et al. 1998; Burger, Lavery, and Gochfeld 1994, Lundstedt-Enkel et al. 2005	**Advantages:** Nonintrusive method for collecting and evaluating presence of COCs in wildlife. Relatively simple and low cost. **Disadvantages:** None reported.	**Analyte capability:** All chemical classes

Method: Dietary assimilation efficiencies		
Description: Absorption efficiency represents the net result of absorption and elimination. Feeding studies are designed to estimate absorption efficiency based on accumulated chemical residues. The fraction of the chemical retained in the organisms relative to that ingested is the assimilation efficiency. **Measurement endpoints:** Chemical levels in food and residual in feces. Also may involve measuring chemical levels in target organism tissue, organelles, and developing fetus. **Test organisms:** All, but most typically fish, birds, and mammals. **References:** None	**Advantages:** Most direct measure of how much of a contaminant in food is retained by the target organism. **Disadvantages:** Difficult to adequately capture fish fecal matter. Useful for birds and mammals but can be time- and resource-intensive.	**Analyte capability:** All chemical classes